14.582 International Trade II
— Lecture 10: Gains from Trade (Theory) —

Today's Plan

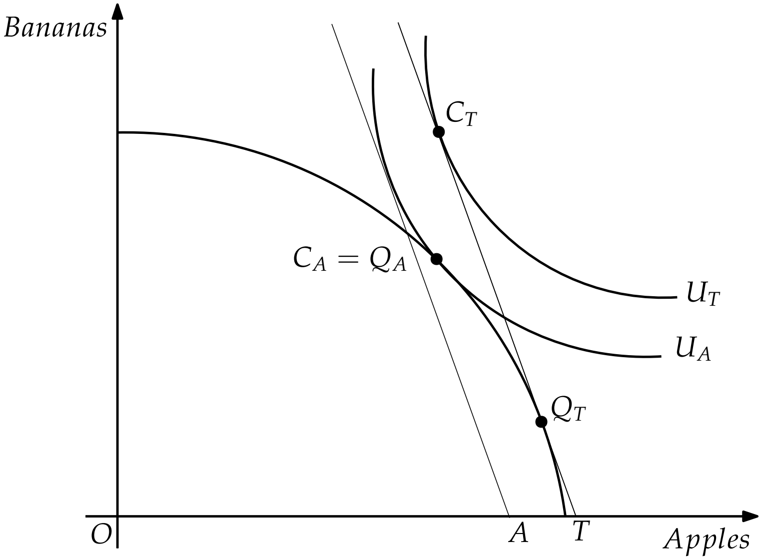
1. Neoclassical Benchmark: CR (2018)
2. New Trade Models, Same Old Gains: ACR (2012)
3. Beyond ACR's (2012) Equivalence Result: CR (2013)

1. Neoclassical Benchmark

Valuation of the Gains from Trade

- Two equilibria: Trade (T) and Autarky (A)
- Prices: p_T and p_A
- Utility: U_T and U_A
- Gains from Trade (GT) = welfare cost of autarky = money that country would be willing to pay to avoid going from T to A
- Expressed as a fraction of initial GDP:

$$GT = 1 - \frac{e(p_T, U_A)}{e(p_T, U_T)}$$



$Bananas$
C_T
$C_A = Q_A$
U_T
U_A
Q_T
O
A
T
$Apples$

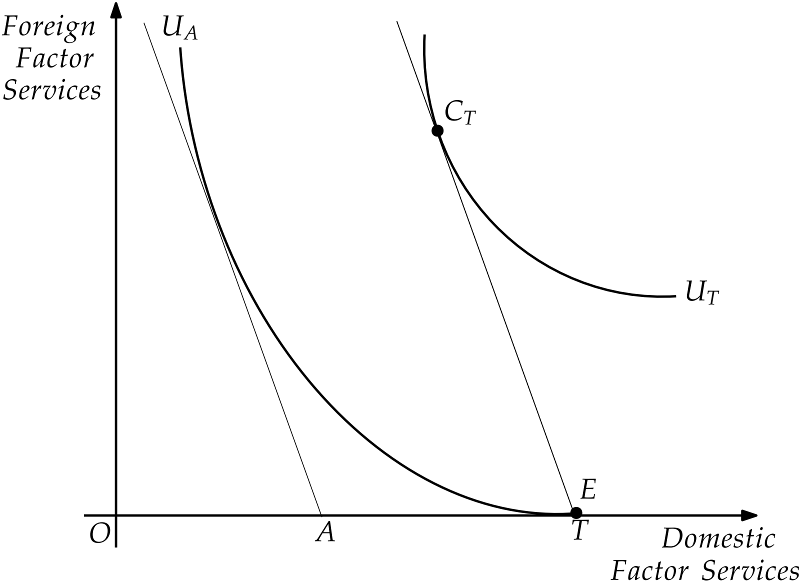
Let Us Scale It Up?

- In practice, countries produce and consumer MANY goods
  - US has positive exports in 8,500 HS-10 digit product categories
  - plenty of product differentiation even within these categories
- Potential strategy to estimate GT:
  - Estimate production sets and indifference curves around the world
  - Compute counterfactual autarky equilibrium
  - Solve for p_A and U_A
  - Use previous formula
- Scaling up the textbook approach requires A LOT of information
  - Not just own-price and cross-price elasticities within a given industry
  - But also US smart phones vs. French red wine, Japanese hybrid cars vs. Costa-Rican coffee etc.

The Factor Approach

- In 14.581, we have discussed Adao, Costinot, and Donaldson (2017)
- ACD have proposed an approach to reduce the dimensionality of what is required for counterfactual analysis
- ACD's Strategy:
  - Exploit equivalence between neoclassical economies and "reduced exchange economies" in which countries simply trade factor services
  - Reduced factor demand = "sufficient statistics" for counterfactuals
- Same observation applies to measurement of GT
  - Instead of estimating production and demand functions around the world, we only need to estimate reduced factor demand = demand for factor services embodied in goods purchased from around the world

The Factor Approach



Parallel with New Good Problem

- Parallel between valuation of GT and "new good" problem in IO
- In order to evaluate the welfare gains from the introduction of a new product (e.g. Apple Cinnamon Cheerios, minivan), we can:
  - Estimate the demand for such products
  - Determine the reservation price at which demand would be zero
  - Measure consumer surplus by looking at the area under the (compensated) demand curve
- We can follow a similar strategy to measure GT:
  - foreign factor services are just like new products that appear when trade is free, but disappear under autarky

From Factor Demand to GT

- Recall definition of expenditure function:

$$e(p, U) = \min_{\{c_i\}}\{\sum_i p_i c_i | u(\{c_i\}) \geq U\}$$

- Assume one domestic factor (numeraire) and one foreign factor (p)
- Envelope Theorem (Shepard's Lemma in this context) implies:

$$\begin{aligned} de(p, U) &= q_F dp \\ \iff d \ln e(p, U) &= \frac{pq_F}{e(p, U)} d \ln p = \lambda_F(\ln p, U) d \ln p \end{aligned}$$

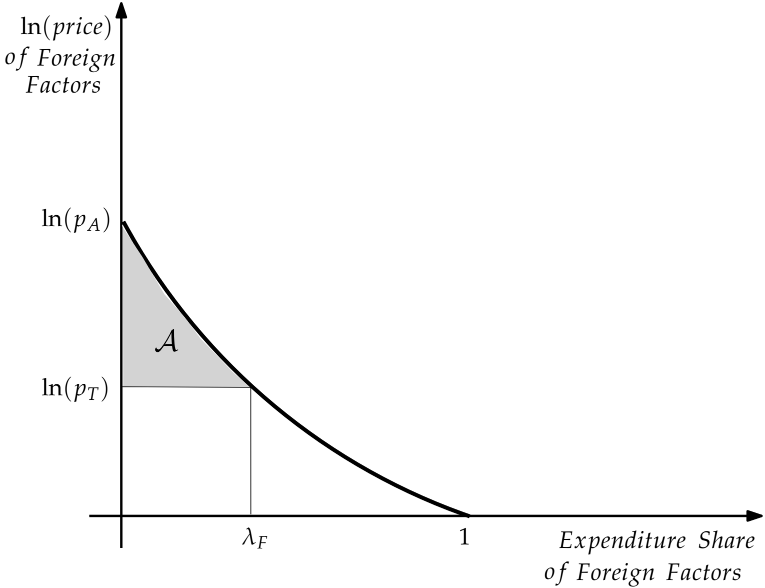
- Integrating between $\ln p_T$ and $\ln p_A$ for $U = U_A$:

$$\ln e(p_A, U_A) - \ln e(p_T, U_A) = \int_{\ln p_T}^{\ln p_A} \lambda_F(x, U_A) dx \equiv \mathcal{A}$$

- Noting that $e(p_A, U_A) = e(p_T, U_T)$

$$GT = 1 - \exp(-\mathcal{A})$$

Integrating Below the (Compensated) Demand Curve



An Analytical Example: CES

- Suppose that factor demand is CES

$$\lambda_F(\ln p, U) = \frac{\exp(-\varepsilon \ln p)}{1 + \exp(-\varepsilon \ln p)}$$

- This leads to

$$\mathcal{A} = \int_{\ln p_T}^{\infty} \frac{\exp(-\varepsilon x)}{1 + \exp(-\varepsilon x)} dx = \frac{\ln(1 + p_T^{-\varepsilon})}{\varepsilon}$$

- Since CES demand system is invertible, we can also express relative price of foreign factor services as a function of initial expenditure share

$$\lambda_F = \frac{p_T^{-\varepsilon}}{1 + p_T^{-\varepsilon}} \Longleftrightarrow 1 + p_T^{-\varepsilon} = \frac{1}{1 - \lambda_F}$$

- Combining theprevious expressions, we get

$$GT = 1 - \exp\left(\frac{\ln(1 - \lambda_F)}{\varepsilon}\right) = 1 - \lambda_D^{1/\varepsilon}$$

Take-Away From the Previous Formula

- CES is a very strong functional-form restriction
  - Popular in the trade literature because tractable
  - No reason why it should be the best guide to estimate GT in practice
- But CES formula nicely captures the 2 key issues for valuation of GT:
  1. How large are imports of factor services in the current trade equilibrium?
  2. How elastic is the demand for these imported services along the path from trade to autarky?
- **Basic idea:** If we do not trade much or if the factor services that we import are close substitutes to domestic ones, then small GT

Some Issues to Keep in Mind

- **Aggregation:**
  - There may not be a single "domestic" and a single "foreign" factor
    - True under CES, but not in general
  - For foreign factor services, one can create a Hicks-composite good (whose price get arbitrarily large under autarky)
  - For domestic factor services, no way around the fact that relative autarky prices need to be computed
- **Measurement:**
  - Global input-output linkages makes it harder to measure spending on foreign factor services (Recall Johnson and Noguera 2012)
  - Global input-output linkages also create distinction between foreign and traded factor services (all traded factors disappear under autarky)
- **Welfare:**
  - Whose expenditure function? What if there are winners and losers from trade? How should we trade-off gains and losses?

2. New Trade Models, Same Old Gains: ACR (2012)

Motivation

- **New Trade Models**
  - Micro-level data have lead to **new questions** in international trade:
    - How many firms export?
    - How large are exporters?
    - How many products do they export?
  - New models highlight **new margins** of adjustment:
    - From inter-industry to intra-industry to intra-firm reallocations
- **Old question:**
  - How large are GT?
- **ACR's question:**
  - How do new trade models affect the magnitude of GT?

ACR's Main Equivalence Result

- ACR focus on gravity models
  - PC: Armington and Eaton & Kortum '02
  - MC: Krugman '80 and many variations of Melitz '03
- Within that class, welfare changes are ($\hat{x} = x'/x$)

$$\hat{C} = \hat{\lambda}^{1/\varepsilon}$$

- **Two sufficient statistics** for welfare analysis are:
  - Share of domestic expenditure, λ;
  - Trade elasticity, ε
- **Two views** on ACR's result:
  - Optimistic: welfare predictions of Armington model are more robust than you thought (better microfoundations)
  - Pessimistic: within that class of models, micro-level data do not matter (only shape of foreign factor demand—here, CES—does)

Primitive Assumptions

Preferences and Endowments

- **CES utility**
  - Consumer price index,

$$P_i^{1-\sigma} = \int_{\omega \in \Omega} p_i(\omega)^{1-\sigma} d\omega,$$

- **One factor of production:** labor
  - $L_i \equiv$ labor endowment in country i
  - $w_i \equiv$ wage in country i

- **Linear cost function:**

$$C_{ij}(\omega, t, q) = \underbrace{q w_i \tau_{ij} \alpha_{ij}(\omega)\, t^{\frac{1}{1-\sigma}}}_{\text{variable cost}} + \underbrace{w_i^{1-\beta} w_j^{\beta} \xi_{ij} \phi_{ij}(\omega)\, m_{ij}(t)}_{\text{fixed cost}},$$

q : quantity,
τ_{ij} : iceberg transportation cost,
$\alpha_{ij}(\omega)$: good-specific heterogeneity in variable costs,
ξ_{ij} : fixed cost parameter,
$\phi_{ij}(\omega)$: good-specific heterogeneity in fixed costs.

Primitive Assumptions

Technology

- **Linear cost function:**

$$C_{ij}\left(\omega, t, q\right) = q w_i \tau_{ij} \alpha_{ij}\left(\omega\right) t^{\frac{1}{1-\sigma}} + w_i^{1-\beta} w_j^{\beta} \xi_{ij} \phi_{ij}\left(\omega\right) m_{ij}\left(t\right)$$

$m_{ij}\left(t\right)$: cost for endogenous destination specific technology choice, t,

$$t \in \left[\underline{t}, \overline{t}\right], \; m_{ij}' > 0, \; m_{ij}'' \geq 0$$

- **Linear cost function:**

$$C_{ij}\left(\omega, t, q\right) = q w_i \tau_{ij} \alpha_{ij}\left(\omega\right) t^{\frac{1}{1-\sigma}} + w_i^{1-\beta} w_j^{\beta} \xi_{ij} \phi_{ij}\left(\omega\right) m_{ij}\left(t\right)$$

- Heterogeneity across goods

$$G_j\left(\alpha_1, ..., \alpha_n, \phi_1, ..., \phi_n\right) \equiv \left\{\omega \in \Omega \mid \alpha_{ij}\left(\omega\right) \leq \alpha_i,\ \phi_{ij}\left(\omega\right) \leq \phi_i,\ \forall i\right\}$$

- **Perfect competition**
  - Firms can produce any good.
  - No fixed exporting costs.
- **Monopolistic competition**
  - Either firms in i can pay $w_i F_i$ for monopoly power over a random good.
  - Or exogenous measure of firms, $\overline{N}_i < \overline{N}$, receive monopoly power.
- Let N_i be the measure of goods that can be produced in i
  - Perfect competition: $N_i = \overline{N}$
  - Monopolistic competition: $N_i < \overline{N}$

Macro-Level Restrictions

Trade is Balanced

- Bilateral trade flows are

$$X_{ij} = \int_{\omega \in \Omega_{ij} \subset \Omega} x_{ij}(\omega)\, d\omega$$

- **R1** *For any country* j,

$$\sum_{i \neq j} X_{ij} = \sum_{i \neq j} X_{ji}$$

  - Trivial if perfect competition or $\beta = 0$.
  - Non trivial if $\beta > 0$.

- **R2** *For any country j,*

$$\Pi_j / \left(\sum_{i=1}^{n} X_{ji}\right) \text{ is constant}$$

where Π_j : aggregate profits gross of entry costs, $w_j F_j$, (if any)

  - Trivial under perfect competition.
  - Direct from Dixit-Stiglitz preferences in Krugman (1980).
  - Non-trivial in more general environments.

- *Import/Labor demand system*

$$(\mathbf{w}, \mathbf{N}, \boldsymbol{\tau}) \rightarrow \mathbf{X}$$

- **R3**

$$\varepsilon_j^{ii'} \equiv \partial \ln \left(X_{ij} / X_{jj} \right) / \partial \ln \tau_{i'j} = \begin{cases} \varepsilon < 0 & i = i' \neq j \\ 0 & \textit{otherwise} \end{cases}$$

- Note: symmetry and separability.
- Note also: Import/Labor demand system is a function of **N**.
    - Potential distinction between neoclassical and non-neoclassical model
    - Recall IRS through love of variety
    - But R2 will guarantee that **N** does not respond to shocks

Macro-Level Restriction

CES Import/Labor Demand System

- The *trade elasticity* ε is an *upper-level* elasticity: it combines
  - $x_{ij}(\omega)$ (*intensive margin*)
  - Ω_{ij} (*extensive margin*)
- R3 $\implies$ complete specialization.
- R1-R3 are not necessarily independent
  - If $\beta = 0$ then R3 $\implies$ R2.

Macro-Level Restriction

Strong CES Import/Labor Demand System (AKA Gravity)

- **R3'** The IDS satisfies

$$X_{ij} = \frac{\chi_{ij} \cdot M_i \cdot (w_i \tau_{ij})^{\varepsilon} \cdot Y_j}{\sum_{i'=1}^{n} \chi_{i'j} \cdot M_{i'} \cdot (w_{i'} \tau_{i'j})^{\varepsilon}}$$

  where χ_{ij} is independent of $(\mathbf{w}, \mathbf{M}, \boldsymbol{\tau})$.
- Same restriction on $\varepsilon_j^{ii'}$ as R3 but, but additional structural relationships
- R3 allows the elasticity with respect to trade costs and wages to be different, R3' does not.

Welfare results

- State of the world economy:

$$\mathbf{Z} \equiv (\mathbf{L}, \boldsymbol{\tau}, \boldsymbol{\xi})$$

- *Foreign shocks*: a change from $\mathbf{Z}$ to $\mathbf{Z}'$ with no domestic change.

Equivalence (I)

- **Proposition 1:** *Suppose that R1-R3 hold. Then*

$$\widehat{W}_j = \widehat{\lambda}_{jj}^{1/\varepsilon}.$$

- **Implication:** 2 sufficient statistics for welfare analysis $\widehat{\lambda}_{jj}$ and ε
- **Basic Idea:**
  - Factor demand is CES + CES system is invertible
  - Changes in the relative price of foreign factors (=TOT) can be inferred from changes in $\widehat{\lambda}_{jj}$, given knowledge of the elasticity of demand ε

New Trade Models, Same Old Gains

- Proposition 1 is an *ex-post* result... a simple *ex-ante* result:
- **Corollary 1:** *Suppose that R1-R3 hold. Then*

$$\widehat{W}_j^A = \lambda_{jj}^{-1/\varepsilon}.$$

- Factor demand is CES $\Rightarrow$ Back to the CES formula for GT
- New margins affect structural interpretation of ε
    - ...and composition of gains from trade (GT)...
    - ... but size of GT is the same
    - Hence the title of ACR: New Trade Models, Same Old Gains (so far)

Equivalence (II)

- A stronger ex-ante result for **variable trade costs** under R1-**R3'**:
- **Proposition 2:** *Suppose that R1-R3' hold. Then*

$$\widehat{W}_j = \widehat{\lambda}_{jj}^{1/\varepsilon}$$

where

$$\widehat{\lambda}_{jj} = \left[\sum_{i=1}^{n} \lambda_{ij} \left(\hat{w}_i \hat{\tau}_{ij}\right)^{\varepsilon}\right]^{-1},$$

and

$$\widehat{w}_i = \sum_{j=1}^{n} \frac{\lambda_{ij} \hat{w}_j Y_j \left(\hat{w}_i \hat{\tau}_{ij}\right)^{\varepsilon}}{Y_i \sum_{i'=1}^{n} \lambda_{i'j} \left(\hat{w}_{i'} \hat{\tau}_{i'j}\right)^{\varepsilon}}.$$

- ε and $\{\lambda_{ij}\}$ are sufficient to predict $\widehat{W}_j$ (ex-ante) from $\hat{\tau}_{ij}$, $i \neq j$.

Taking Stock

- ACR consider models featuring:
    - (i) Dixit-Stiglitz preferences;
    - (ii) one factor of production;
    - (iii) linear cost functions; and
    - (iv) perfect or monopolistic competition;

  with three macro-level restrictions:
    - (i) trade is balanced;
    - (ii) aggregate profits are a constant share of aggregate revenues; and
    - (iii) a CES import demand system.
- Equivalence for ex-post welfare changes and GT
    - under R3' equivalence carries to ex-ante welfare changes

Melitz and Redding (2013)

- Argue that micro heterogeneity matters: New Models, New Gains
- **Obs 1:** *Technological change that goes from no heterogeneity (Krugman 80) to heterogeneity (Melitz 03) would change ε and GT*
  - We are adding an extensive margin. So elasticity increases
  - This reduces GT. Far from "GT higher because productivity goes up"
- **Obs 2:** *Away from monopolistically competitive models considered by ACR (Pareto case), trade elasticity may not be constant.*
  - Definitely true. But point of ACR is that conditional on macro, micro does not matter. Not that micro cannot affect macro.
  - Do we need firm heterogeneity to explain that factor demand is not CES? Empirically, is this only alternative to scarcity of macro data?

3. Beyond ACR's (2012) Equivalence Result:

CR (2013)

Departing from ACR's (2012) Equivalence Result

- **Other Gravity Models:**
  - Multiple Sectors (Costinot, Donaldson, and Komunjer 2012)
  - Tradable Intermediate Goods (Caliendo and Parro 2015)
  - Multiple Factors
  - Variable Markups (ACDR 2012)
  - Economic Geography (Allen and Arkolakis 2014, Redding 2016)
- **Beyond Gravity:**
  - More flexible functional forms (Adao, Costinot, and Donaldson 2017)
  - PF's sufficient statistic approach
  - Revealed preference argument (Bernhofen and Brown 2005)
  - More data (Costinot and Donaldson 2011)

Back to Armington

1. Add multiple sectors
2. Add traded intermediates

Multiple sectors, GT

- Nested CES: Upper level EoS ρ and lower level EoS ε_s
- Recall gains for Canada of 3.8%. Now gains can be much higher: $\rho = 1$ implies $GT = 17.4\%$

Tradable intermediates, GT

- Set $\rho = 1$, add tradable intermediates with Input-Output structure
- Labor shares are $1 - \alpha_{j,s}$ and input shares are $\alpha_{j,ks}$ ($\sum_k \alpha_{j,ks} = \alpha_{j,s}$)

Tradable intermediates, GT

	% GT_j	% GT_j^{MS}	% GT_j^{IO}
Canada	3.8	17.4	30.2
Denmark	5.8	30.2	41.4
France	3.0	9.4	17.2
Portugal	4.4	23.8	35.9
U.S.	1.8	4.4	8.3

Combination of micro and macro features

- In Krugman, free entry $\Rightarrow$ scale effects associated with total employment
- In Melitz, additional scale effects associated with sales in each market
- In both models, trade may affect entry and fixed costs
- All these effects do not play a role in the one sector model
- With multiple sectors and traded intermediates, these effects come back

Gains from Trade

....	Canada	China	Germany	Romania	US
Aggregate	**3.8**	**0.8**	**4.5**	**4.5**	**1.8**

Gains from Trade

....	Canada	China	Germany	Romania	US
Aggregate	3.8	0.8	4.5	4.5	1.8
MS, PC	**17.4**	**4.0**	**12.7**	**17.7**	**4.4**

Gains from Trade

....	Canada	China	Germany	Romania	US
Aggregate	3.8	0.8	4.5	4.5	1.8
MS, PC	17.4	4.0	12.7	17.7	4.4
MS, MC	**15.3**	**4.0**	**17.6**	**12.7**	**3.8**

Gains from Trade

....	Canada	China	Germany	Romania	US
Aggregate	3.8	0.8	4.5	4.5	1.8
MS, PC	17.4	4.0	12.7	17.7	4.4
MS, MC	15.3	4.0	17.6	12.7	3.8
MS, IO, PC	**29.5**	**11.2**	**22.5**	**29.2**	**8.0**

Gains from Trade

....	Canada	China	Germany	Romania	US
Aggregate	3.8	0.8	4.5	4.5	1.8
MS, PC	17.4	4.0	12.7	17.7	4.4
MS, MC	15.3	4.0	17.6	12.7	3.8
MS, IO, PC	29.5	11.2	22.5	29.2	8.0
MS, IO, MC (Krugman)	**33.0**	**28.0**	**41.4**	**20.8**	**8.6**

Gains from Trade

....	Canada	China	Germany	Romania	US
Aggregate	3.8	0.8	4.5	4.5	1.8
MS, PC	17.4	4.0	12.7	17.7	4.4
MS, MC	15.3	4.0	17.6	12.7	3.8
MS, IO, PC	29.5	11.2	22.5	29.2	8.0
MS, IO, MC (Krugman)	33.0	28.0	41.4	20.8	8.6
MS, IO, MC (Melitz)	**39.8**	**77.9**	**52.9**	**20.7**	**10.3**

What Do We Learn from CGE Models?

- Contribution of recent CGE work:
  - Link to theory—"mid-sized models"
  - Compare models that match same macro data
  - Quantify mechanisms
    - Multiple sectors, tradable intermediates
    - Market structure matters, but in a more subtle way
- For purposes of estimating GT:
  - Very indirect way to estimate demand for foreign factor services
    - Some elasticities are estimated, some are not
    - Idiot's law of elasticities: all elasticities $= 1$ until shown otherwise
  - Relevant elasticity= elasticity of substitution between domestic and all foreign factors combined, not one foreign source versus another
    - gravity equation typically recovers the latter
  - What about oil? Shouldn't it lower the elasticity of demand for foreign factor services? (Fally and Sayre 2017)

Recent and Future Research

- **Factor Demand Approach:**
  - How flexible can we be when trying to estimate factor demand directly?
    - Adao, Costinot, and Donaldson (2017) explore mixed CES
    - What is the best way to combine macro and micro data?
    - How do we deal with global input-output linkages?
- **Issues set aside in this lecture:**
  - Dynamic gains from trade (will come back to that when discussing growth)
  - Distortions (will come back to that when discussing markups)
  - Redistribution (Antras, de Gortari, and Itskhoki JIE 2017, Galle, Rodriguez-Clare, and Yi 2017, Costinot and Werning 2018)
- **One final note:** positive $\neq$ policy implications
  - Next lecture we will study optimal trade policy in Melitz (2003). It is very different than in Krugman (1980) or Eaton and Kortum (2002)